ensuring on-the-spot assistance and providing responsive customer service were major elements contributing to the program's success.

Clearly, establishing credibility was paramount to the project's success. The FBCB2 team accomplished this by becoming extremely proficient and efficient at their jobs. Additionally, the entire team was totally committed to mission accomplishment.

In the Nov-Dec 2002 *Army AL&T* magazine, BG Michael Mazzucchi, Program Executive Officer Command, Control and Communications Tactical, stated that we have "made great strides in providing the warfighter valuable tools to understand the tactical situation more clearly, make decisions with more confidence and react more quickly to changing battlefield conditions." The FBCB2 fielding during *Operation Enduring Freedom* was successful because of several key factors: the 1st Bde, 82nd Abn. Div.'s acceptance and support for training and installation of the FBCB2 Blue Force Tracking system; and the civilian team from PM FBCB2 and Northrop Grumman. As the Commander, 2nd Batallion, 1st Bde., 82nd Abn. Div., summarized, "FBCB2 is the best tactical situational awareness tool that I've ever used."

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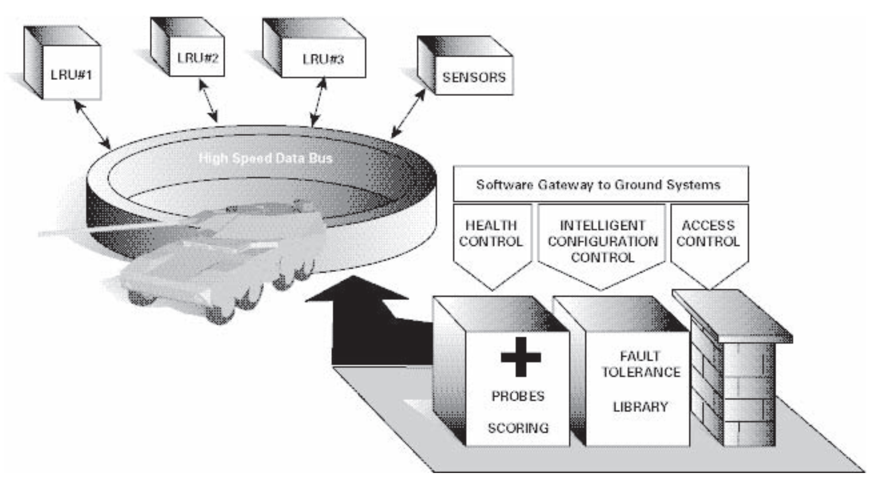
Ground Combat Vehicles: Present and Future Diagnostics and Prognostics

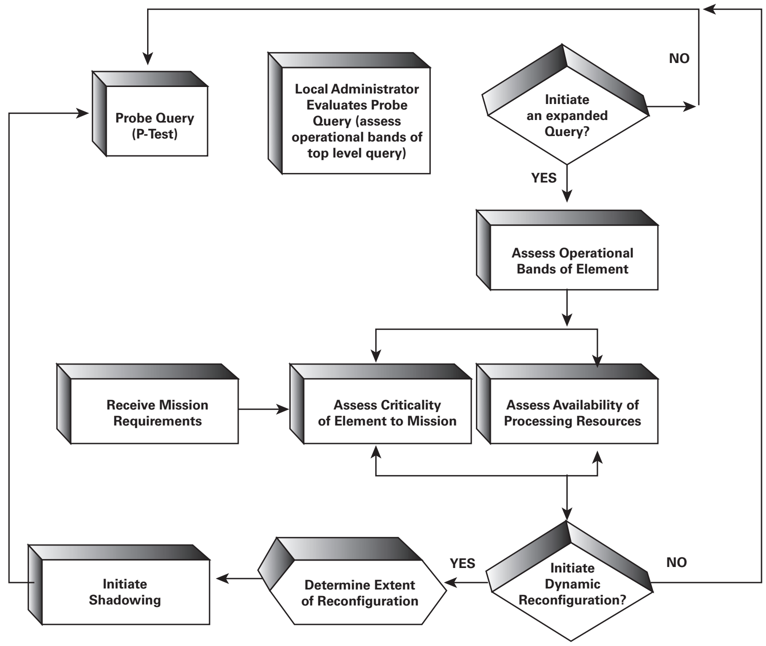
Dr. Elena N. Bankowski and Christopher Miles

The diagnostics capability of ground combat vehicles (GCVs) has to be compatible with the Army Diagnostic Improvement Program. Present systems are capable of performing health monitoring and health checks using internal embedded resources.



They employ standard sensors and data busses that monitor data signals, measurements and built-in tests. These devices provide a comprehensive data source to accomplish complete and accurate system-level diagnostics and fault isolation at line replaceable unit (LRU) level. They provide system health monitoring and prognostics capability for subsystems consisting of engine, transmission, power pack interface, gauge cluster unit and others. Prognostics routines provide diagnostics capability to identify the cause of failure, when failure is predicted, and corrective action to prevent unscheduled maintenance action.

A GCV's health status and prognostic information are displayed to operator, crew and maintenance personnel. Present systems use a common data/information interchange network per standards defined in the Joint Technical Architecture to provide access to vehicle health data. The technologies used in present systems include embedded diagnostics, combat maintainers, revised maintenance concepts and schematic viewers. Implementation of these technologies significantly reduced maintenance hours on GCVs. For example, today's Main Battle Tanks (MBTs) contain a multitude of processors, yet combat systems such as the Abrams provide redundancy only between the hull electronics unit and the turret electronics unit. The Abrams employs duplicate processors hosting redundant software in different vehicle compartments. More than half a million lines of software code span multiple processors. The software in the Abrams tank was created in a highly sophisticated development and testing environment.



System Health Check Process

The U.S. Army Next Generation Software Engineering Technology Area (Next Generation) proposed Statistical Usage Testing (SUT) in the Post-Production Software Support (PPSS) project for the Army's MBTs. Usage models were supported by the Markov chain process, test management, test-case generation and statistical testing. We implemented a prototype tool for composing top-level models and lower-level submodels. This model-compose utility allowed for the development of submodels similar to subroutine development in programming. The major lessons learned from the SUT project were:

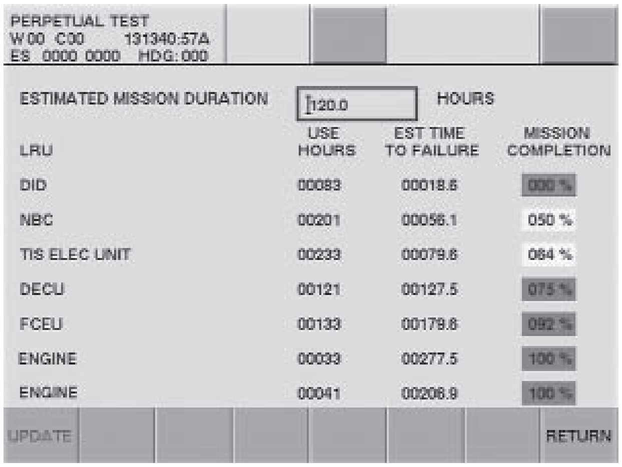
- SUT can positively impact MBT testing because the focus is on operational usage.
- Usage modeling is feasible in the MBT environment.
- Usage modeling uncovers issues that relate to behavior and testing.
- A logical and complementary relationship exists between the current testing approach used by Next Generation and SUT.

SUT modeling techniques were applied to the Driver's Integrated Display, a component of the tank's soldier-machine interface. Since then, additional LRUs with increasing complexity have been modeled using SUT. In applying modeling techniques, a high degree of complexity was observed, consisting of the numbers of screens to be modeled and the amount of information that could impact a tester's next action. These challenges were overcome using some innovative approaches. Next Generation investigated the feasibility of using SUT in the PPSS test environment. The primary motivation was the realization that there were not enough test assets, people or time to test the MBT software for each release. The SUT's approach was to determine better ways to test increasingly complex systems and system-of-systems in the future. Significant progress has been made, and efforts are now underway to combine SUT with other approaches to automated testing to scale it up even further.

Future Diagnostics and Prognostics

The proposed new technology for health monitoring, diagnostics and prognostics of future systems will use a federated software and probes approach. Gauges will determine if the system operates within acceptable performance bands by monitoring data provided by the probes. Health monitoring systems will use mission models to make intelligent choices considering tasks criticality. Prognostics of system LRUs will be based on probes data and statistical usage models.

Future weapon platforms will host a significant increase in software. The processing burden of the front-line vehicles will require a further increase in processing capability. Next-generation weapon systems processing requirements will grow with the incorporation of intelligent decision aids, sensor fusion and advanced communications. A future system will have 2 x 106 configuration combinations. Cost, reliability, space and mission requirements will preclude achieving redundancy with dedicated, embedded processors that duplicate functionality.



Proposed Prognostic Screen

The Next Generation vision is that a collection of general-purpose processors connected to a common bus will be scattered throughout the GCV and assigned dynamically to the various vehicle control and mission-specific tasks as required. This approach reduces cost and provides greater effective redundancy because any healthy processor can be assigned to any task. Next Generation system processes require extensive monitoring and analysis capabilities to track whether the weapon system is operating properly. A robust reconfiguration capability is required to reorganize task assignment to processors to respond to hardware and software failures and changed mission requirements.

The proposed technology will provide better health and situation control (HSC) for GCV diagnostics and prognostics. HSC continually tests the processing elements with probe/agent technology. Algorithms within HSC assess the processors' health based on a criticality scoring system that considers mission requirements. Probes are launched by HSC query processing elements. The probed data are sent to a gauge that has a variable sensitivity or gain. Statistical usage models and criticality scoring control the gauge's sensitivity. In response to the gauge, the replicating process launches agents that can insert anomalous events for diagnostic purposes. In this context, a probe is a subset of an agent having only the ability to query without affecting framework, I/O protocol or quality of service.

Each weapon system fitted with the HSC will control self-repair and reconfiguration of onboard processors using a statistical-based intelligent scoring system that considers function criticality in current battlefield situations. HSC is a software system that will enhance the performance of a weapon system by providing on-the-fly reconfiguration to accommodate the loss or malfunction of processing elements or to optimize onboard performance capability. Selected software components of soldier-machine interface in a crew station will be modeled using HSC architecture modeling techniques. The hardware environment will be modeled so that HSC analysis tools can select compatible hosts from candidate processors.

Missions will also be modeled so that HSC tools can make intelligent choices considering task criticality. HSC will detect faults and select the optimal crew station configuration to maintain essential functionality in response to current battlefield conditions. HSC will also construct correct configurations of software to load onto a GCV for combinations of weapons systems, sensors and missions. It will collect usage and runtime error data that can be used to improve the software development and testing processes. HSC-collected usage information and runtime error patterns will be fed into Next Generation SUT models to improve the modeling fidelity and software testing process. Success of this aspect of HSC will be measured by the reduction in time for the SUT models to identify, isolate and repair errors. HSC architecture descriptions will be used to improve SUT usage modeling techniques and processes. The HSC probe controller will serve as an agent for the HSC controller, reporting the health of the weapon system elements. Off-vehicle probes will also be launched to assess the health of companion vehicles within the operational unit.

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